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(54) Title
**A HEAT EXCHANGER DEVICE FOR AN AIR CONDITIONING SYSTEM**

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(56) Prior Art Documents
**US 3236056**
**US 4494380**

(57) Claim

1. A heat exchanger device for an air conditioning system, said heat exchanger device (29) comprising first and second heat exchanger elements (30, 31) defining separate first and second flow passages (32, 33) for heat transporting medium, and a thermoelectric unit (45) arranged between and having opposite heating and cooling surfaces in heat conductive contact with the first and second heat exchanger elements, respectively,
characterised in that a plurality of thermoelectric units (45) arranged in side-by-side relationship are sandwiched between the heat exchanger elements (30, 31), and in that each heat exchanger element (30, 31) defines a tortuous flow passage (32, 33) therein having a length being several times the maximum dimension of the heat exchanger element, or a plurality of coextending separate flow passages each having a small cross-sectional area.

# A HEAT EXCHANGER DEVICE FOR AN AIR CONDITIONING SYSTEM

The present invention relates to a heat exchanger device for an air conditioning system, especially for conditioning the air in cabins of cars or other vehicles.

Air conditioning systems for cars comprising thermoelectric cooling units are disclosed in US Patent No. 3.236.056 and in the published Swedish Patent Application No. 8704395. The air conditioning systems disclosed in these documents comprise one or more thermoelectric units which are sandwiched between straight water conduits having a rectangular cross-section and forming part of heat transfer circuits.

The known air conditioning systems have a relatively small cooling capacity and this may be the reason why the documents are silent about the source of the electric energy which has to be supplied to the thermoelectric units of the system. This energy source is apparently supposed to be the standard battery and electricity supply system already available in an existing standard car in which the air conditioning system is to be installed.

The object of the present invention is to provide a heat exchanger device for an air conditioning system of the above type by means of which the capacity and/or efficiency of the air conditioning system may be substantially increased.

The heat exchanger device according to the present invention comprises first and second heat exchanger elements defining separate first and second flow passages therein for heat transporting medium, and a thermoelectric unit, such as a so-called Peltier element, arranged between and having opposite heating and cooling surfaces in heat conductive contact with the first and second heat exchanger element, respectively, and the heat exchanger device according to the invention is characterised in that a plurality of thermoelectric units arranged in side-by-side relationship are sandwiched between

times the maximum dimension of the heat exchanger element or a plurality of coextending separate flow passages each having a small cross-sectional area.

The heat exchanger device according to the invention may secure an efficient cooling of the warm sides of the thermoelectric units and an efficient heating of the cold sides of these units, whereby the overall thermal efficiency of the air conditioning system may be increased. Furthermore, the capacity of the air conditioning system may be adapted to that desired by using a suitable number of thermoelectric units and by dimensioning the heat exchanger device correspondingly.

The flow passages formed in any of the heat exchanger elements may comprise two or more tortuous coextending flow passages or a plurality of substantially straight flow passages extending in the longitudinal direction of the heat exchanger. As an example, each heat exchanger element may define one or a few separate tortuous flow passages covering substantially the area contacting the thermoelectric units, or a plurality of separate adjacent flow passages extending in the longitudinal direction of the heat exchanger element. In order to obtain substantially the same effect, the total cross-sectional area or areas of the flow passage or passages should be substantially the same in either case.

The thermoelectric units may, for example, be of the type marketed by Marlow Industries Inc., such as Model SP1996.

In principle, the heat exchanger device may have any suitable shape allowing the selected number of thermoelectric units to become sandwiched between the heat exchanger elements. In the preferred embodiment, however, the heat exchanger element has a flat, block-like shape, so as to allow a maximum number of thermoelectric units to be included in the heat exchanger device in relation to the total volume of this device.

to the element at least along the contour of the element. The plate-like thermoelectric unit or Peltier element may then be arranged between the cover plates of the first and second heat exchanger elements, for example by means of thermo conductive paste or adhesive. Alternatively or additionally, the heat exchanger elements may be clamped together by releasable mechanical clamping means, such as screws or bolts, whereby an optimum specific contact pressure between the heat exchanger elements and the thermoelectric units sandwiched therebetween may be adjusted.

The tortuous flow passages defined in the heat exchanger elements may have any desired shape securing a good heat transfer between the heat transporting medium, usually water or an aqueous liquid, flowing through the flow passages and the adjacent side surfaces of the thermoelectric units. However, preferably at least one of the first and second flow passages defines one or more meander-shaped patterns which have been found to be especially efficient.

Each of the flow passages defined by the heat exchanger elements has an inlet and an outlet which may be located at any suitable position of the element. Preferably, each of the heat exchanger elements has the inlet as well as the outlet arranged at the same end. Thus, the first heat exchanger element may have its inlet and outlet positioned at one end while the first element may have its inlet and outlet positioned at the opposite end of the heat exchanger device. In such case each of the circuits of the air conditioning system for heat transporting medium has to be connected to only one end of the heat exchanger device.

Each of the heat exchanger elements may have a substantially rectangular outline, and the flow passage defined in each element may then comprise a transversely extending meander-shaped flow passage section at each end of the heat exchanger element interconnected by a longitudinally extending meander-

device being formed by three superposed heat exchanger elements, the flow passages formed in the outer elements being interconnected. Thermoelectric units may then be arranged between the inner heat exchanger element and any of the outer elements so that the warm sides of the thermoelectric units are in contact with the outer elements while the cold sides are in contact with the inner heat exchanger element. In the preferred embodiment, however, the heat exchanger device comprises only a pair of heat exchanger elements, and the length of the flow passage adjacent to the warm sides of the thermoelectric units may then be longer than that of the other flow passage adjacent to the cold side of the thermoelectric units.

The heat exchanger elements should be made from a material with good heat conductive characteristics. Thus, the first and second heat exchanger elements are preferably made from aluminum, copper and/or from alloys thereof.

The present invention further provides a system for conditioning air in a room, such as a cabin of a vehicle, such system comprising a heat exchanger device according to the invention as described above, the first and second passages of the heat exchanger device being included into first and second closed liquid circuits, respectively, each liquid circuit including a radiator and means for circulating liquid therethrough. One of these radiators may be arranged inside and one being arranged outside the room in which the air is to be conditioned. When the air conditioning system is used for conditioning the air of a vehicle cabin, one of the liquid circuits may include part of the liquid cooling system of a combustion engine for driving the vehicle. The radiator in the cabin may then selectively be provided with hot water from the driving engine or with cold water from the heat exchanger device.

The invention will now be further described with reference to the drawings, wherein

sage of the heat exchanger device 23, a circulating pump 25, a radiator 26 arranged outside the car cabin and having an associated blower or fan 27, and a liquid expansion tank 28. The cabin radiator 18 may be disconnected from the water jacket of the engine 10 by means of solenoid valves 29.

The heat exchanger device 23 will now be described in more detail. The device 23 comprises a pair of plate-like elements 30 and 31 made from metal, such as aluminum. A tortuous channel or groove 32 and 33, respectively, is formed in a side surface of each of the elements 30 and 31. The channel 32 formed in the element 30 comprises a meander-shaped channel section 34 arranged at one end of the substantially rectangular element 30, a corresponding meander-shaped channel section 35 arranged at the opposite end of the element, and an interconnecting, longitudinally extending, meander-shaped channel section 36. The end channel section 35 is connected to a liquid inlet 37, and the end channel section 34 is connected to a liquid outlet 38 via a longitudinally extending straight channel segment 39. Through holes 40 are positioned along the periphery of the element 30 and through holes 41 are positioned along the central line of the element. A circumferential groove 42 for receiving a sealing ring or gasket is formed outside the channel sections 34-36 and 39.

Apart from the fact that the total length of the channel 33 in the plate-like element 31 is substantially greater than the total length of the channel 32 in the element 30, the elements 30 and 31 are alike. Therefore, the reference numerals used in Fig. 6 are the same as those of Fig. 5. However, in Fig. 6 a mark has been added to the reference numerals.

**The channels or grooves 32 and 33 in each of the plate-like elements 30 and 31, respectively are covered by a thin, heat conductive cover plate 43 and 44, respectively, and each of the cover plates are in sealing engagement with a gasket or a**

The air conditioning system illustrated in Fig. 1 operates as follows. When the on-off switch 13 is in its off position the solenoid valves 29 are open while the valve 22 is closed. In this state the cabin radiator 18 and the blower 19 may heat the air in the car cabin in a conventional manner.

When the switch 13 is moved to its on position the valves 29 are closed while the valve 22 is opened and electric current is supplied to the Peltier elements 45 of the heat exchanger device 23, to the pumps 21 and 25 and to the fan 27. Water in the second water circuit 20 will now be circulated through the flow passage defined by the channel 32 in the heat exchanger device 23 whereby the water will be efficiently cooled by the Peltier elements 45 in a manner known per se. The cold water flowing through the cabin radiator 18 will now cool the cabin air being circulated in the cabin by means of the blower 19. At the same time the warm side of the Peltier elements 45 will be cooled by water or another liquid being circulated in the third water circuit 24 which includes the channel 33 of the heat exchanger device 23, by means of the pump 25. The heat removed from the heat exchanger device 23 will be given off to the outside air via the outside radiator 26.

In the air conditioning system shown in Fig. 7 the parts similar to those shown in Fig. 1 has been indicated by the same reference numerals.

In the embodiment shown in Fig. 7 the second water circuit has been made independent of the cooling water circuit 17 and comprise a separate radiator 47 arranged opposite to the blower 19 and a liquid expansion tank 48. Furthermore, the operation of the various electrical devices of the system is controlled by an electric control unit 49. It is appreciated that the air conditioning system shown in Fig. 7 may be installed in a car without interfering with the existing electrical and cooling systems of the car.

CLAIMS

1. A heat exchanger device for an air conditioning system, said heat exchanger device (23) comprising first and second heat exchanger elements (30, 31) defining separate first and second flow passages (32, 33) for heat transporting medium, and a thermoelectric unit (45) arranged between and having opposite heating and cooling surfaces in heat conductive contact with the first and second heat exchanger elements, respectively,
characterised in that a plurality of thermoelectric units (45) arranged in side-by-side relationship are sandwiched between the heat exchanger elements (30, 31), and in that each heat exchanger element (30, 31) defines a tortuous flow passage (32, 33) therein having a length being several times the maximum dimension of the heat exchanger element, or a plurality of coextending separate flow passages each having a small cross-sectional area.

2. A heat exchanger device according to claim 1, wherein each heat exchanger element (30, 31) has a flat, block-like shape.

3. A heat exchanger device according to claim 1 or 2, wherein each heat exchanger element has an elongated, preferably substantially rectangular shape.

4. A heat exchanger device according to claim 3, wherein the maximum longitudinal dimension of each heat exchanger element substantially exceeds the maximum transverse dimension thereof.

5. A heat exchanger device according to any of the claims 1-4, wherein the ratio between the cross-sectional areas of the flow passage or the sum of the cross-sectional areas of the flow passages, and the areas of the heat exchanger surface being in contact with the thermoelectric units is

7. A heat exchanger device according to any of the claims 1-6, wherein the flow passage in at least one of said first and second heat exchanger elements (30, 31) is a channel or groove (32, 33) formed in a side surface of the element.

8. A heat exchanger device according to claim 7, wherein said first and second flow passages are channels or grooves (32, 33) formed in opposite, adjacent side surfaces of the first and second heat exchanger elements (30, 31).

9. A heat exchanger device according to claim 7 or 8, wherein the channel or groove (32, 33) in each heat exchanger element (30, 31) is covered by a cover plate (43, 44) sealed to the element along the contour of the element.

10. A heat exchanger device according to claim 8 and 9, wherein the plate-like thermoelectric units (45) are arranged between the cover plates (43, 44) of the first and second heat exchanger elements (30, 31).

11. A heat exchanger device according to any of the claims 1-10, wherein the heat exchanger elements (30, 31) are clamped together by releasable clamping means, such as screws or bolts (46).

12. A heat exchanger device according to any of the claims 1-11, wherein at least one of the first and second flow passages (32, 33) defines one or more meander-shaped patterns (34-36).

13. A heat exchanger device according to any of the claims 1-12, wherein the flow passage (32, 33) of each heat exchanger element (30, 31) has an inlet and an outlet (37, 38) arranged at one end of the heat exchanger element (30, 31).

14. A heat exchanger device according to claim 12 and 13, wherein each of the heat exchanger elements (30, 31) has a

20. A system according to claim 19 for conditioning the air of a vehicle cabin, wherein the first liquid circuit (20) includes part of the liquid cooling system (17) of a combustion engine (10) for driving the vehicle.

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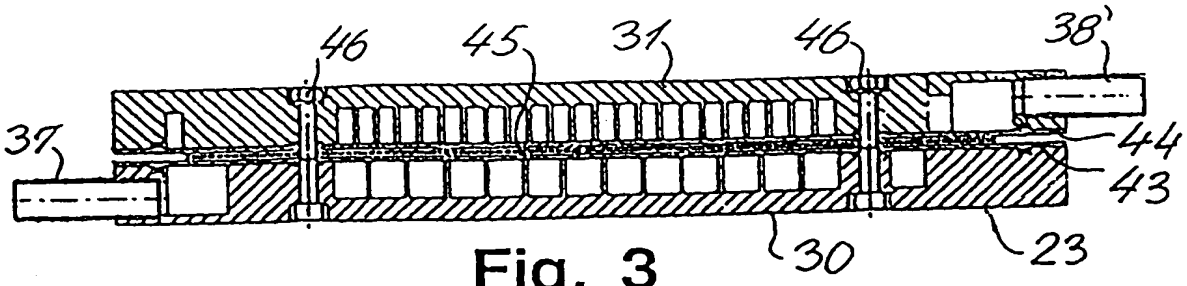


Fig. 3

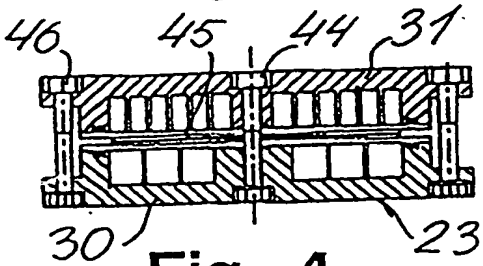


Fig. 4

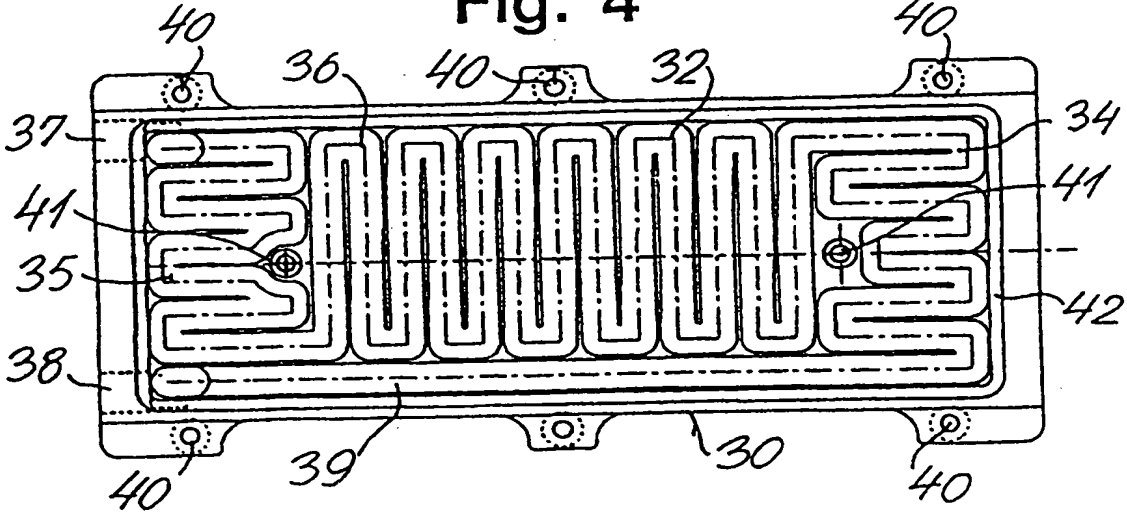


Fig. 5

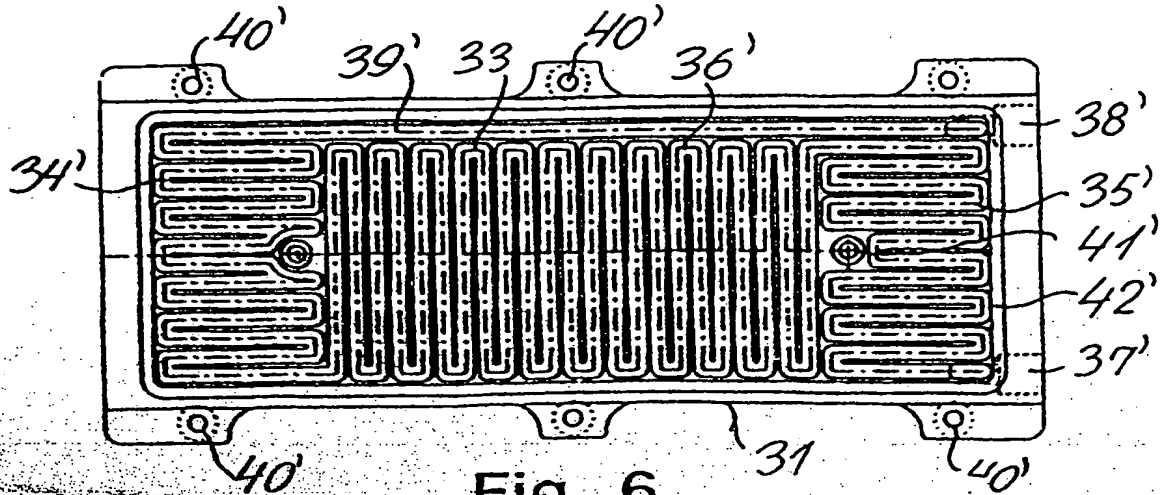


Fig. 6

# INTERNATIONAL SEARCH REPORT

Int .onal Application No
PCT/DK 96/00531

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B60H1/00 F24F5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B60H F24F F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 3 236 056 A (E.L. PHILLIPS ET AL.) 11 January 1965 cited in the application see the whole document --- | 1-8, 10-12, 17-20 |
| Y | US 4 494 380 A (CROSS RONALD H) 22 January 1985 see column 3, line 7 - column 4, line 23; figures --- | 1-8, 10-12, 17-20 |
| A | EP 0 338 283 A (KOSLOW TECHN CORP) 25 October 1989 see abstract --- | 1-6, 11-13,15 |
| A | GB 2 267 338 A (CHANG PEN YEN) 1 December 1993 --- -/-- | |

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 24 March 1997 | 02.04.97 |

| Name and mailing address of the ISA | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. ( + 31-70) 340-2040, Tx. 31 651 epo nl, Fax: ( + 31-70) 340-3016 | Marangoni, G |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

Inv onal Application No
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| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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| US 4494380 A | 22-01-85 | NONE | |
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| GB 2267338 A | 01-12-93 | NONE | |
| SE 8704395 A | 12-05-89 | NONE | |